The PATH to 5G

Diego Lozano de Fournas, Solutions Manager
Tokyo, February 2018
The path to 5G

Agenda

- Market perspective
  - 5G Drivers
  - Technical Implications of 5G and Challenges
  - 5G Opportunities Today

- How can Spirent Lifecycle Service Assurance (LSA) Help?
  - Spirent Landslide in the Lab for evolution to 5G testing
  - Spirent VisionWorks Mobility Service Assurance (MSA) for 5G
Market Perspective
Drivers for 5G

Continuous capacity demands

Safely introducing NFV

Assuring Hybrid Networks (Physical & Virtual)

Massive IoT
Critical IoT
Enhanced MBB
New Traffic Mixes
LPWA technology

The growth of IoT and evolution towards 5G

The need for agility & cost reduction

The need to differentiate Quality
The promises of 5G

**Goals**

✓ Massive devices density
✓ Increased speeds
✓ Massive data volumes
✓ Minimum latency for critical services
✓ Universal applications support
✓ Efficient network usage (eg; virtualization, slicing, MEC, distributed NFs, …)
✓ Efficient network management (eg; automated OSS, DevOps rollout, …)
5G Services’ vision

Future IMT

Enhanced Mobile Broadband

Gigabytes in a second

Smart Home/Building

3D video, UHD screens

Work and play in the cloud

Augmented reality

Industry automation

Self Driving Car

Mission critical application e.g. e-health

Voice

Smart City

Massive Machine Type Communications

Ultra-reliable and Low Latency Communications
5G a $3 trillion opportunity

**Enhanced Mobile Broadband (eMBB)**

- $153 billion market (2022)
- $60 billion market (2022)

**Massive Machine Type Comms. (mMTC)**

- $156 trillion market (2020)
- $255 billion market (2019)
- $23 billion market (2020)
- $121 billion market (2022)

**Ultra-reliable, Low Latency Comms. (URLLC)**

- $195 billion market (2022)
- $400 billion market (2019)
- $152 billion market (2020)
- $225 billion market (2022)

Evolution from personal technology to general purpose technology
Technical Implications of 5G

Essential items
What are the technical implications?

New RAN (Cloud RAN)

C-Plane U-Plane Separation

Virtualization

Network Slicing

New Core

5G Network Architecture with NFV
Industry’s path to 5G

1. Enhancing 4G to extend life and incorporate 5G concepts
   - + NB-IOT
   - + DECOR
   - + CUPS

2. 5G Non-Standalone
   Early 5G RAN deployments will use 4G core with dual 4G/5G RAN connectivity

3. True Native 5G:
   Framework in place, cloud native
   Needs more detailed standards definition

Key trials and pre-deployment:

- Virtualization: 2017
- CUPS: 2018
- Option 3: 2018
- Distributed Computing: 2019
- True 5G/Legacy: 2019
Example: Challenges of the Evolution towards 5G

**A Evolving Architecture**
- Virtualized Core
- Virtualized Services
- Virtualized Edge (MEC)
- Control User Plane Separation (CUPS)
- New IoT nodes (SCEF)

**B New Capabilities**
- Network Slicing (DECOR)
- IoT Optimization (NB-IoT & CAT-M1)
- Non Standalone mode (5G NR: LTE assisted with pre-5G Core (EPC))

**C Performance**
- New Radio and Performance
- Slice & CUPS Performance
- Low Latency
- IoT (bursts & high signaling)
- Carrier Aggregation
- Services (Streaming Video, Gaming, VoLTE, MBB)
Example of key features to test, validate & assure

**A.1 Virtual EPC**

- Test Agent

**B.1 Massive & Critical IoT**

- SUT
- Emulated

**C.1 Slicing & 5G NR**

- Dedicated Core Network (DCN)

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**Efficiently validate & proactive assure new vEPC nodes & services through active testing & emulation**

**Validate Core Network can support new IoT traffic without impacting traditional voice & data services**

**Validate pre-5G Network capabilities (i.e. DECOR) deliver the required differentiated service**
5G Opportunities Today
5G Services to be rolled out soon

Use cases

- **Broadband Wireless**
  Fixed Wireless Access to provide high bandwidth services (>1 Gbs) to Residential and SME customers

- **Internet Offload**
  Offload internet traffic at the network edge using MEC, CUPS

- **Connected Things**
  Autonomous Vehicle, Vehicle to Vehicle, Vehicle to Pedestrian, Internet Connected Vehicle, AR Enabled Vehicle

- **Smart Things**
  Massive IoT (Factory, Grid, City, etc), IoT Security, Automation, Network Slicing

- **Network Migration**
  SDN/NFV network architecture, DevOps, support services

- **Mobile Internet Security**
  Security applied to the 5G Mobile Core

- **QoE (Video, AR, VR)**
  QoE for Video, Augmented Reality, Virtual Reality using MEC and CUPS

- **Network Automation**
  Automation and Orchestration leveraging NFVi for the entire deployment life-cycle

- **Public Safety**
  Public Safety (Emergency) as a network slice in 5G

- **Enterprise and SP**
  Enterprise integration via 5G, Small Cell, Wifi, …
## Tech Companies that should investigate business models in 5G

<table>
<thead>
<tr>
<th>Tech Company</th>
<th>Business Models</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LTE NEM</strong></td>
<td>• Leverage expertise in mobility&lt;br&gt;• Progressively expand offering from 4G towards 5G&lt;br&gt;• Build offerings for all sorts of service providers, not just mobile carriers</td>
</tr>
<tr>
<td><strong>5G NEM</strong></td>
<td>• Virtualization and DevOps removes entry barriers from 4G&lt;br&gt;• 5G is a complete new network, not an evolution of 4G</td>
</tr>
<tr>
<td><strong>Router NEM</strong></td>
<td>• Leverage expertise in routing and high speed packet processing&lt;br&gt;• CUPS offers business models for low-cost routing platforms/nodes</td>
</tr>
<tr>
<td><strong>Mobile Service Provider</strong></td>
<td>• 4G and 5G Service differentiation based on slicing&lt;br&gt;• Penetrate residential market with fixed wireless&lt;br&gt;• Early adoption of IoT in preparation for 5G</td>
</tr>
<tr>
<td><strong>MSO/Cable Service Provider</strong></td>
<td>• Leverage cable infrastructure to provide 5G fronthaul and backhaul&lt;br&gt;• Expand offering for residential market with fixed wireless&lt;br&gt;• Add mobile core network</td>
</tr>
<tr>
<td><strong>Enterprise</strong></td>
<td>• Differentiate enterprise services via slicing&lt;br&gt;• Integrate data centers deep in the network&lt;br&gt;• Leverage cloud native infrastructure and micro-services</td>
</tr>
</tbody>
</table>
How can Spirent LSA Help?
Spirent Landslide for evolution to 5G testing

Lab testing
Spirent Landslide and the 5G Evolution

- IoT
- DECOR
- R14 CUPS
- MC-PTT
- 5G RAN/4G CORE
- Dual-Connect
- True 5G Nodes
- Native CUPS
- Native Slicing
- Massive IoT

2017
- IoT LS
- DECOR LS
- R14 CUPS LS
- MC-PTT LS
- 5G RAN/4G CORE LS
- Dual-Connect LS
- True 5G Nodes LS
- Native CUPS LS
- Native Slicing LS
- Massive IoT LS

2018
- IoT LS
- DECOR LS
- R14 CUPS LS
- MC-PTT LS
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- IoT LS
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2020+
- IoT LS
- DECOR LS
- R14 CUPS LS
- MC-PTT LS
- 5G RAN/4G CORE LS
- Dual-Connect LS
- True 5G Nodes LS
- Native CUPS LS
- Native Slicing LS
- Massive IoT LS

- Lab testing
- Deployment
- Landslide availability

Pending on standards release
Landslide testing features for...

1. Enhancing 4G to extend life and incorporate 5G concepts
Spirent Landslide vs 4G to 5G System Architecture Evolution

- NB-IoT & CAT-M Devices & Traffic Mixes Device emulation
- PSM and eDRX features
- Control Plane & User Plane Optimization for Data transmission
- NIDD Delivery
- C-SGN and S11u testing
- Diameter Extensions: T6a/T6b, S6t
- IoT Mobility
- IoT Call modelling
- Emulators: C-SGN, SCEF, Slices
Spirent Landslide vs 4G to 5G System Architecture Evolution

- **IoT**
  - ✓ DECOR
  - R14 CUPS
  - MC-PTT

**Slicing/DECOR Testing**
- ✓ EPC/Slices Emulation
- ✓ UE Usage Type definition
- ✓ Slices design
- ✓ Slice routing testing
- ✓ Per-slice performance
- ✓ Backhaul design

### Vertical
- **Broadband**
  - Device A
  - Device B

- **Massive IoT**
  - Device C

- **Automotive**
  - Device D
  - Device X

### RAN Slice #1
- C-RAN
- NR

### RAN Slice #2
- CN-UP
- C-RAN
- NR

### RAN Slice #3
- MEC
- CN-UP
- C-RAN
- NR

### CN Slice #1
- vCache
- vDPI
- vEPC

### CN Slice #2
- vGW
- vEPC

### CN Slice #3
- vVPN
- vEPC

- **High Throughput**
- **Low Packet Loss**
- **Low Latency**

**Network Sliced Vertical**
- Broadband
- Massive IoT
- Automotive
- Device A
- Device B
- Device C
- Device D
- Device X

**Device Types**
- Broadband
- Massive IoT
- Automotive
Spirent Landslide vs 4G to 5G System Architecture Evolution

- **IoT**
- **DECOR**
- **✓ R14 CUPS**
- **MC-PTT**

**Network Components:**
- **UE**
- **(E-UTRAN) Access Network**
- **SGW**
- **PGW**
- **Policy Control Function (PCRF)**
- **Mobility Management (MME)**
- **Home Subscriber Server (HSS)**
- **Data Networks (DN)**

**Signaling Interfaces:**
- **S1-U**
- **S1-AP**
- **S11**
- **S6a**
- **Gx**
- **SGi**

**Note:**
- Control: Dashed lines
- Data: Solid lines
Spirent Landslide vs 4G to 5G System Architecture Evolution

SGW-C/PGW-C:
- Control plane only
- Holds complexity of CUPS

SGW-U/PGW-U:
- User Plane processing only
- Low-cost virtual/HW routers
- Auto-scaling for virtual

CUPS Testing
- Sxa, Sxb validation
- CP and UP performance
- UP Mobility
- Multi-Node UP verification
- UP auto-scaling
- Function distribution
- Slicing

Landslide CUPS Testing and Emulation

- Control
- Data

IoT
DECOR
✓ R14 CUPS
MC-PTT

SGW-U/PGW-U:
- User Plane processing only
- Low-cost virtual/HW routers
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SGW-C:
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SGW-U:
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- Low-cost virtual/HW routers
- Auto-scaling for virtual

PGW-U:
- User Plane processing only
- Low-cost virtual/HW routers
- Auto-scaling for virtual

UE
(E-UTRAN) Access Network

Home Subscriber Server (HSS)

Data Networks (DN)
Landslide testing features for...

2. 5G Non-Standalone
5G RAN with 4G core
Spirent Landslide vs 4G to 5G System Architecture Evolution

- **5G RAN/4G CORE**
  - Dual-Connect

![Diagram of 5G and 4G networks](image)

**Landslide**

- **Home Subscriber Server (HSS)**
- **Mobility Management (MME)**
- **SGW-C**
- **PGW-C**
- **Policy Control Function (PCRF)**
- **Data Networks (DN)**

**UE/RAN Testing**

- ✓ EPC/Slices Emulation
- ✓ Dual-connect 4G/5G testing
- ✓ RAN performance testing
- ✓ Device fallback testing
- ✓ Backhaul design

**Dual-Connectivity 4G/5G**

- 5G Device connects to both 4G and 5G RAN
- 5G Device falls back to 4G when 5G not available

**S1-U Bearer Switching**

- Network decides S1-U bearer based on services requirements
- Only one S1-U active at a time
Spirent Landslide vs 4G to 5G System Architecture Evolution

**CORE/E2E Testing**
- ✓ 4G/5G RAN/Devices Emulation
- ✓ MME Emulation for dual-connect 4G/5G
- ✓ Dual-connect 4G/5G testing
- ✓ Fallback emulation
- ✓ Per-service ‘switching’ testing
- ✓ E2E Core performance testing
- ✓ Backhaul design

**Dual-Connectivity 4G/5G:**
- 5G Device connects to both 4G and 5G RAN
- 5G Device falls back to 4G when 5G not available

**S1-U Bearer Switching:**
- Network decides S1-U bearer based on services requirements
- Only one S1-U active at a time
Landslide testing features for...

3. True Native 5G
5G RAN with
5G core

True 5G Nodes
Native CUPS
Native Slicing
Massive IoT
3GPP Standards Rollout – 5G Standalone Options

5G-NR eMBB workplan

<table>
<thead>
<tr>
<th>RAN #74</th>
<th>RAN #75</th>
<th>RAN #78</th>
<th>RAN #80 (Rel-15 completion)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016</td>
<td>2017</td>
<td>2018</td>
<td></td>
</tr>
<tr>
<td>Q4</td>
<td>Q1</td>
<td>Q2</td>
<td>Q3</td>
</tr>
<tr>
<td>Q4</td>
<td>Q1</td>
<td>Q2</td>
<td>Q3</td>
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5G study

5G NR Work Item

5G NR NSA Completion

5G NR SA Completion

Stage 3 completion for Non-Standalone 5G-NR

Stage 3 completion for Standalone 5G-NR

NSA Option 3 family ASN.1

Rel-15 ASN.1 for SA & NSA

Option 3 Definition

Standalone Definition

NSA = Non StandAlone

SA = StandAlone

EPC core ("Option 3") & LTE anchor
4G to 5G System Architecture Evolution

5G Nodes
- Native CUPS
- Native Slicing
- Massive IoT

E2E Testing
- AMF Nodal Device/5G RAN emulation
- N1, N2, N3 interfaces validation
- Throughput and latency testing
- E2E service emulation & quality analysis
- MEC validation

Network Nodes:
- Authentication Server Function (AUSF)
- Unified Data Management (UDM)
- Access/Mobility Mgmt Function (AMF)
- Session Management Function (SMF)
- Policy Control Function (PCF)
- Application Function (AF)
- User Plane Functions (UPF)
- Data Networks (DN)
- (New Radio) Access Network
- UE
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- Data Networks (DN)
- (New Radio) Access Network
- UE

Network Interfaces:
- N1, N2, N3, N4, N5, N6, N7, N8, N9, N10, N11, N12, N13, N14, N15

Network Connections:
- Control Data

Landslide
4G to 5G System Architecture Evolution

**5G Nodes**
- Native CUPS
- Native Slicing
- Massive IoT

**Control Plane/E2E Testing**
- SMF Nodal Device/5G RAN emulation
- N11,N3 interfaces validation
- Session Management performance
- E2E service emulation & quality analysis

- **Access/ Mobility Mgmt Function (AMF)**
- **Unified Data Management (UDM)**
- **User Plane Functions (UPF)**
- **Policy Control Function (PCF)**
- **Application Function (AF)**
- **Authentication Server Function (AUSF)**
- **Session Management Function (SMF)**
- **Data Networks (DN)**

**UE**

**Landslide**

- **(New Radio) Access Network**

**N1** **N2** **N3** **N4** **N5** **N6** **N7** **N8** **N9** **N10** **N11** **N12** **N13** **N14** **N15**

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Control Data

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4G to 5G System Architecture Evolution

5G Nodes

- Native CUPS
- Native Slicing
- Massive IoT

User Plane Testing

- UPF Nodal with UE/RAN/AMF/SMF emulation
- N4,N3 interfaces validation
- User Plane performance
- E2E service emulation & quality analysis

Network Nodes

- Authentication Server Function (AUSF)
- Unified Data Management (UDM)
- Access/Mobility Mgmt Function (AMF)
- Session Management Function (SMF)
- Policy Control Function (PCF)
- Application Function (AF)
- User Plane Functions (UPF)
- Data Networks (DN)

Network Interfaces

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- N3
- N4
- N5
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- N7
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- N9
- N10
- N11
- N12
- N13
- N14
- N15

Landslide

UE

(New Radio) Access Network

Control

Data
### 5G Challenges and Spirent Landslide Support 1/2

<table>
<thead>
<tr>
<th>Dynamic / Opportunity</th>
<th>Issues / Challenges</th>
<th>How can Spirent Landslide help</th>
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</thead>
</table>
| **New 5G RAN architecture** | Testing 5G New Radio against pre-5G Virtualized Core & features (i.e. Slicing, NB-IoT) = Lack of virtualized Core vendors/features | ✓ EPC emulation  
✓ R14 CUPS Emulators  
✓ DECOR Core Emulation  
✓ Core Emulation Dual-Connect Support  
✓ IPsec |
| **New 5G Core Architecture** | New nodes and interfaces with a complex relationship between them (extensive functional and performance testing required)  
Powerful control plane paired with low-cost deployment of user plane nodes | ✓ R14 CUPS testing and Emulators  
✓ IoT emulation  
✓ DECOR RAN emulation  
✓ RAN Dual-Connect  
✓ Landslide R15 Nodal and Node test cases |
| **Use of NFV in 5G** (i.e. C-RAN, Core & DCs) | Multi-Vendor complexity (interoperability & predictability).  
Performance  
Ported apps rather than Cloud Native.  
How to achieve Carrier Grade Software | ✓ Landslide Validating virtual Core for supporting 5G services (VNFs in isolation and Progressive End-to-End)  
✓ Landslide automation and orchestration APIs |
## 5G Challenges and Spirent Landslide Support 2/2

<table>
<thead>
<tr>
<th>Dynamic / Opportunity</th>
<th>Issues / Challenges</th>
<th>How Spirent can help</th>
</tr>
</thead>
</table>
| **Network Slicing**    | Guarantee correct design of each slice based on serviced vertical:  
  • Distribute functions for optimized QoS  
  • Reduce OPEX  
  • Differentiate services | ✓ DECOR testing and Slice emulation  
 ✓ R14 CUPS  
 ✓ Combined Smartphone and IoT device emulation  
 ✓ Real World user plane emulation |

| **4G/5G Services and Performance** | Provide tailored solution (ie; scale, quality), for each 5G service vertical. Eg:  
  • Video (high-throughput)  
  • Automotive (low latency)  
  • IoT (low packet loss) | ✓ Landslide High performance platforms  
 ✓ Virtualization and DevOps methodologies  
 ✓ DECOR and Slicing testing/emulation, R14 CUPS, Dual-connect validation  
 ✓ Combined Smartphone and IoT device emulation with BH Call Modeling  
 ✓ Real World user plane emulation |
The 5G Service Differentiation Challenge

“The network will become a commodity. Success is about service differentiation” – Tier 1 SP Exec

Deliver High-Quality Differentiated Services

Launch Much Faster at Much Lower Cost

Use Standardized Platforms & Technology

Months to Days

The Service Lifecycle

$$$$ to $$
Lifecycle Service Assurance for Service Differentiation

LSA Solution Suite
Accelerate the Service Lifecycle, Reduce Costs and Differentiate Service Quality with LSA

✓ Rapidly on-board new services
✓ Increase agility
✓ Reduce operational costs across the hybrid network
VisionWorks Solutions

- **Solutions**
  - Customer Experience Assurance
  - Mobility Service Assurance
  - Transport Service Assurance

- **Use Cases**
  - VisionWorks Analytics
  - VisionWorks Controller
  - VisionWorks Active Test Agents

- **Production Networks: Virtual, Physical & Hybrid**

- **OSS, MANO Interfaces**
VisionWorks: Test anywhere in network automated with End-to-End visibility of each slice
VisionWorks **Active Assurance** reduces time to market of new 5G enablers.
VisionWorks enabling Service Differentiation

Current

Quality of Service based

Limited to Core and Bearer

Application Specific (Netflix, NFL, Youtube)

Future (5G)

Quality of Service based
- Latency, Bandwidth, Datarate, Security

RAN/Transport/Applications
- enabled by Network Slicing

Market Specific
- Health, Transport, Industrial, Retail, Consumer
VisionWorks enabling Service Differentiation

Roll Out: Virtualization and slicing are great examples

Key UseCases
✓ VNF turn-up SLA
✓ VNF Onboarding SLA
✓ VNF Performance SLA
✓ VNF Re-cycle SLA
✓ End-to-End Service Validation
VisionWorks enabling Service Differentiation

Monitoring: per-slice Active testing

VisionWorks KPI report card

<table>
<thead>
<tr>
<th>Slice 1</th>
<th>Slice 2</th>
<th>Slice 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Packet Loss</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Jitter</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Latency</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

VisionWorks can monitor end-to-end KPI’s for each slice – Packet Loss, Jitter, Latency
VisionWorks enabling Service Differentiation

**VW VTA ready for Service differentiation – functional and scalable**

- Variable bandwidth per active test agent
- Per active test agent traffic profiling
- Emulates live services such as
  - VoLTE
  - VoWiFi
  - NB-IoT, Cat-M
  - Video call
  - Video streaming
  - SMS/MMS
  - E911 routing
  - Internet Availability
  - Network Latency: TCP/HTTP/RTP
  - Applications Traffic: Youtube, Facebook etc

Active Assurance of end-to-end Network Slice is critical to meet Service Differentiation of SLAs
US Tier 1 Provider - Carrier Aggregation Service Differentiation

VisionWorks Architecture

Automated Active Testing
CA Cell performance

Test Manager

Results Aggregator and Data Mining for all Test Locations
Feed Analytics Dashboards

VisionWorks Analytics
US Tier 1 Provider - Carrier Aggregation Service Differentiation

Sample Dashboards ranking performance

Alert!!
Summary

Driven by consumers and carriers demands, 5G is approaching fast!
- Understand 5G challenges
- Choose best path of evolution
- Be first to market
- Differentiate

Spirent Landslide is here to help (Lab testing)
- Experienced in new mobile technologies testing
- First to market in 5G testing
- Enables testing of all different paths of evolution to 5G
- Suited for DevOps roll outs

Spirent VisionWorks MSA is here to help (Production network)
- Develop, deploy and operate your 5G network with confidence
- Guarantee differentiation through active testing and analytics
- Reduce operational costs:
  - Gain visibility anywhere in the network
  - Predict, detect and isolate faults in real-time